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# DEPARTMENT OF TRANSPORTATION
# STATE OF GEORGIA

# SPECIAL PROVISION

# PROJECT: XXXXXXX
# XXXXXX COUNTIES
# P.I. NO. XXXXXXX

# SECTION 631 – PERMANENT CHANGEABLE MESSAGE SIGNS

## Section 631 - Permanent Changeable Message Signs

### 631.1 General Description

This Work includes furnishing and installing permanent changeable message sign equipment. Major elements of the CMS system include changeable message signs, sign housing (walk-in or front access), LED modules, LED drivers, power supplies, local changeable message sign controller, roadside CMS cabinet and power service to the controller and sign.

Configure the system to provide motorists with graphics and textual information using changeable message signs placed over or adjacent to designated roadways. Local CMS controllers provide a base level of control of the CMS display. Primary control and command of the local CMS controllers in the system will be through a communication link to a central facility as identified within the project plans. Auxiliary control will be accomplished from other remote locations to the central facility locations, as identified within the project plans, over communication media that may be different than that used for the primary control and command to/from the central facility. Local control and command may be accomplished manually from the local CMS controller by operator input via a keypad on the front of the controller and through the use of a laptop computer connected to one of the data ports of the local CMS controller.

Use only products and materials that meet the requirements of these minimum specifications and are listed on the Department's Qualified Products List. Provide all equipment and materials of like kind and function to be of the exact same manufacture, model, revision, firmware, etc.

#### 631.1.01 Definitions

A. CMS Type 1- Freeway sign with 3 lines of 21 characters (18" – 14x10 font characters) – Walk-in enclosure.

   a. Shall be full matrix (variable text and graphics) sign with minimum of 250 pixel columns and 54 pixel rows.

   b. Pixel Pitch (spacing) shall be 1.33 in (34 mm)

   c. Pixel spacing shall be such that three lines of text (14x10 font characters) shall each have a nominal height of 18 inches.

   d. The sign housing shall be a walk-in enclosure.

B. CMS Type 2 – Freeway sign with 3 lines of 21 characters (18" – 23x15 font characters) – Walk-in enclosure.

a. Shall be full matrix (variable text and graphics) sign with minimum of 400 pixel columns and 96 pixel rows.

b. Pixel Pitch (spacing) shall be 0.81 in (20 mm).

c. Pixel spacing shall be such that three lines of text (23 x 15 font characters) may be displayed each having a nominal height of 18 inches.

d. The sign housing shall be a walk-in enclosure.

C. CMS Type 3 – Freeway sign with 3 lines of 15 characters (18' – 23 x 15 font characters).

a. Shall be a full matrix (variable text and graphics) sign with a minimum of 288 pixel columns and 96 pixel rows.

b. Pixel Pitch shall be 0.81 inches (20 mm)

c. Pixel spacing shall be such that three lines of text (23x15 font characters) shall each have a nominal height of 18 inches.

d. The sign housing shall be a front access enclosure.

D. CMS Type 4 - Arterial sign with 3 lines of 12 characters (7x5 font characters) – Front access enclosure.

a. Shall be a full matrix sign with a minimum of 75 pixel columns and 27 pixel rows.

b. Pixel Pitch shall be 1.75 inches (46 mm)

c. Pixel spacing shall be such that three lines of text (7x5 font characters) shall each have a nominal height of 12 inches.

d. The sign housing shall be a front access enclosure.

E. CMS Type 5 - Arterial sign with 3 lines of 12 characters (15x10 font characters) – Front access enclosure

a. Shall be a full matrix sign with a minimum of 160 pixel columns and 64 pixel rows.

b. Pixel Pitch shall be .081 inches (20 mm)

c. Pixel spacing shall be such that three lines of text (15x10 font characters) shall each have a nominal height of 12 inches.

d. The sign housing shall be a front access enclosure.

## 631.1.02 Related References

### A. Georgia Standard Specifications

Section 150 – Traffic Control

Section 682 – Electrical Wire, Cable, and Conduit

Section 925 – Traffic Signal Equipment

Section 939 – Communication and Electronic Equipment

Section 940 – NaviGAtor Advanced Transportation Management System Integration

### B. Referenced Documents

AASHTO "Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals"

American National Standards Institute (ANSI)

American Society of Testing and Materials (ASTM)

American Welding Society (AWS) Standards

Electronic Industries Association (EIA)

Illumination Engineers Society (IES)

International Municipal Signal Association (IMSA)

ANSI/IPC-T-50, latest version/addendum

MIL-P-13949, latest version/addendum

IPC-2221. latest version/addendum

IPC-D-275, latest version/addendum

MIL-PRF-31032, latest version/addendum

National Electrical Code (NEC)

National Electrical Manufacturers Association (NEMA)

NEMA TS-4, 2004,

National Transportation Communications for ITS Protocol (NTCIP)

Rural Electrification Administration (REA)

Underwriters Laboratory Incorporated (UL)

### C. NTCIP References

This Specification references several NTCIP standards. Each NTCIP Component covered by these Specifications shall implement the most recent version of the standard that has reached the stage of Recommended or higher as of September 20, 2004, including any and all Approved or Recommended Amendments to these standards as of the same date.

The standards that have been referenced by this Specification are listed below.

| NTCIP Number | Title |
|---|---|
| NTCIP 1201:1996 | NTCIP Global Object (GO) Definitions |
| NTCIP 1203:1997 | NTCIP Object Definitions for Dynamic Message Signs (DMS) |
| NTCIP 2001:1996 | NTCIP Class B Profile |
| NTCIP 2101 v01.17 | NTCIP SP-PMPP/RS232 (Point-to-Multi-Point Protocol using RS232 Sub-network Profile) |
| NTCIP 2103 v01.05 | NTCIP SP-PPP/RS232 (Point-to- Point Protocol using RS232 Sub-network Profile) |
| NTCIP 2104 | NTCIP SP-Ethernet (Ethernet Profile) |
| NTCIP 2201 v01.03 | NTCIP TP-Transportation Transport Profile (TP-Null) |
| NTCIP 2202 | NTCIP TP-Internet (TCP/IP and UDP/IP) |
| NTCIP 2301 v01.07 | Simple Transportation Management Framework (STMF) Application Profile |

Note that the last four documents reflect the current trend of the NTCIP standardization effort to define profiles that relate to particular protocol levels in the NTCIP Framework. A protocol stack defined in accordance to NTCIP 2101, NTCIP 2201, and NTCIP 2301 directly corresponds to the protocol stack defined in NTCIP 2001.

### 631.1.03 Submittals

Use only products and materials that meet the requirements of these minimum specifications and are listed on the Department's Qualified Products List. Products appearing on the Qualified Products List (QPL) are exempt from normal submittal requirements. These products have been evaluated by the Office of Traffic Operations and have proven their capability of meeting the appropriate Georgia Department of Transportation Specification. Any of these products may be used without submitting catalogue cuts, sampling or pre-testing. The Contractor shall submit a letter to the Field Engineer, stating which QPL items they will use. The Field Engineer and/or department designee must ascertain that the construction item is the same material identified on the appropriate QPL and will acknowledge receipt of these items in the project diary or as required by the Construction manual.

The following chart provides the Contractor with an outline of the submittal requirements for the equipment and components for these pay items. This chart is to be used as a guide and does not relieve the Contractor from submitting additional information to form a complete submittal package.

The following definitions apply to the submittal requirement terms in the following chart:

**Shop Drawings**: Drawings providing detailed assembly and component layout, used by the manufacturer to assemble or construct the Item.

**Structural Calculation**: Calculations prepared by a registered Professional Engineer, in the state of Georgia, that indicate that the assembly meets all requirements of this specification, the Standard Specifications and AASHTO for wind loading, etc.

**Lab Test Report**: A certified report from an independent laboratory that the component or assembly meets all the requirements of this specification.

**Installation Procedure**: A manual prepared by the manufacturer that indicates the installation procedures for components, sub assemblies or assemblies as outlined in Section 631.1.03 C of this specification.

**Maintenance Procedure**: A manual prepared by the manufacturer that indicates the maintenance of all components, sub assemblies, and assemblies as outlined in Section 631.1.03 M2 of this specification.

**Test Schedule**: A written schedule of the testing required as outlined in Section 631.1.03 C of this specification.

**Test Plan**: A plan developed by the manufacturer to perform the testing required for this item as outlined in Section 631.1.03 F, G, and H, and Section 631.3.06 F1, F2, F3, and F4 of this specification.

**Test Reports**: A report developed by the manufacturer that documents the results of each of the required tests as outlined in Section 631.3.06 F1 of this specification.

**Training Schedule**: A schedule prepared by the Contractor that outlines the time for the required training sessions as outlined in Section 631.3.08 A, of this specification.

**Training Material**: Course material for each of the training sessions required by Section 631.3.08 of this specification.

| Material | Specification Reference | Catalog Cuts | Mfg. Spec. | Shop. Drawings | Structural Calc. | Lab Test Report | Install. Proced. | Maint. Proced. | Test Schedule | Test Plan | Test Reports | Training Schedule | Training Material | Submittal Due Date (Calendar Days After NTP) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre-Installation Test | 631.3.06 F.2 | | | | | | | | x | x | x | | | Plan - 60 Days |
| Proof of Performance Test | 631.3.06 F.3 | | | | | | | | x | x | x | | | Plan - 60 Days |
| Acceptance Test | 631.3.06 F.4 | | | | | | | | x | x | x | | | Plan - 60 Days |
| Training | 631.3.08 A | | | | | | | | | | | x | x | Plan - 90 Days |

### A. General

Clearly identify in the submittals any deviations from the Contract requirements and Specifications. Provide a detailed description of the deviation with the reason for the change. Do not interpret approval of the submittals or shop drawings as approval of any deviation unless such deviation is identified in writing in the submittal letter that is separate from the shop drawings.

### B. As-Built Plans

Furnish four (4) complete half-size 11" x 17" as-built plans signed and sealed by a Professional Engineer registered in the State of Georgia in accordance with the Standard Specifications. Include in the as-built plans all materials and installation work, along with all structural elements and assemblies that are related to the CMS system at a given location. Prepare the as-built plans and show in them all changes and deviations from the original Plans. On each plan sheet, provide the name of the Contractor and any Subcontractors who performed any work shown on the plan sheet. Submit the as-built plans to the Engineer no later than 30 days after the completion of acceptance testing. The burn-in period will not commence until the Engineer approves the as-built plans.

### C. Submittal Data Requirements

Submit submittal data and shop drawings for all equipment, materials, test procedures, and routine maintenance procedures required in this Contract within 60 calendar days after Notice to Proceed and prior to any installation, unless noted otherwise in the Contract documents. Submit available third party test results for required items shown in Pre-Installation Testing. Submit structural foundation, support, and mounting shop drawings for changeable message signs within 90 calendar days after Notice to Proceed.

Submit to the Engineer for approval, two (2) hardcopies and one electronic copy of the manufacturer's descriptive literature, technical data, operational documentation, service documentation, and other materials fully describing the design, equipment, and materials that will be used for all non-structural equipment or materials required in this Specification.

Provide shop drawings for all structural support materials, changeable message sign housing material, and all other special design, non-electrical, non-mechanical fabricated items.

Provide submittal data and shop drawings that are neat, legible, and orderly. Neatly organize each package of submittal data and separate by hardware item. Use the “Material Certification Package Index and Transmittal Form,” contained in Section 105.02 of the standard specifications, for each pay item to document and list all material and components that are included in the submittal package. Any submittal data submitted without the Index/Transmittal form or that is incomplete will be rejected.

Light output of the individual LED pixels shall be in accordance with NEMA TS-4. The manufacturer shall submit third party documentation of compliance.

### D. Submittal Review Demonstration Test Set

Submit demonstration test set(s) for Department evaluation after the Engineer approves the submittal materials for the equipment and materials listed below. The demonstration test sets shall be connected to and operated through the NaviGAtor system by the Engineer. Deliver the test set to the Department at the location specified by the Engineer. Request a delivery and test time a minimum of 30 days in advance. Provide demonstration test sets of the materials, types and quantities as shown below:

- CMS Controller, (quantity 2 )
- CMS Test Display Simulator, if needed (quantity 1 for each controller required)

A demonstration test set shall include all materials, components, assemblies, control software and documentation of the CMS controller of a CMS and shall be complete and fully functional for communications with the NaviGAtor system. The CMS controller and test display simulator shall be configured for locating on a bench top, or else provide a desktop stand to secure the equipment. A CMS test display simulator shall be provided if necessary for full communications with the CMS controller from NaviGAtor, including sign display and pixel status monitoring and dimming operation. The CMS test display simulator is only for use during the demonstration test period and remains the property of the Contractor. Provide a power supply for the CMS controller and display simulator that operates from 120VAC with a NEMA 5-15 cord. Provide RS232 cables for connection of the RS232 communications port(s) on the CMS controller.

Review of the demonstration test set submittal shall be conducted in two parts. The first part of the review shall be performed by the Contractor in the presence of the Engineer and shall include the setup and configuration of the demonstration test set on the NaviGAtor system. The first part of the review shall be conducted during normal Department weekday business hours and shall be conducted for the period of time necessary to the satisfaction of the Engineer. The second part of the review shall be a 60-day period during which the Engineer shall operate and evaluate the demonstration test set with the NaviGAtor system. The second part of the review shall commence only upon the Engineer's approval of the first part of the review. Retrieve the demonstration test set upon completion of the second part of the review as notified by the Engineer.

### E. CMS Test Software

Within 90 days of Notice to Proceed, submit for Department review proposed CMS test software that will be used to verify the functional and performance capabilities of the CMS using the NTCIP protocol stack. The review of the test software will not relieve the Contractor of any requirements to provide a fully functioning CMS that performs in accordance with the Specifications.

### F. Documentation for Electronic Equipment

Provide the documentary items specified in this section for all changeable message sign equipment and materials. The documentary items shall provide a complete and precise technical description of all CMS equipment and materials and shall thoroughly demonstrate that the design and construction of all CMS equipment and materials fully conforms to all requirements of this Specification.

Provide the following documentary items in a neat, legible, clearly identified, and suitably bound fashion:

- Manual fully describing the theory of operation with complete technical data including block diagrams showing operational relationships between major components, wave forms, etc.
- Manual for troubleshooting including flowcharts, test procedures, test points, alignment procedures, etc.
- Electronic schematics on 11" x 17" drawings.
- Pictorial layout of components on circuit boards showing locations of all components and referencing each component to its entry in the parts list/manufacturer's data sheet.
- Complete parts lists/manufacturer's data sheets of all passive and active electrical and electronic components. Parts lists/data sheets shall provide complete technical materials and performance data, environmental specifications, manufacturer's names/part numbers, etc.
- Drawings and materials lists of all equipment and assembly frames, mounting brackets, mechanical items, etc.
- Diagrams of field installation wiring showing all terminal block positions and identifications.
- Recommended routine maintenance procedures and schedules for all equipment and materials.

### G. Pre-Installation Testing

Submit the Pre-installation Test Plan in accordance with this specification. The Pre-Installation Test Plan shall be a detailed and thorough procedure that fully demonstrates that the changeable message sign, local CMS controller, and local CMS controller cabinet meet all requirements of the Specifications. Include the following items within the Pre-Installation Test Plan as a minimum:

- Review of updated documentation.
- Review of updated schematics and drawings.
- Review of electrical design, components, and construction of CMS assembly.
- Review of mechanical design and construction of CMS assembly.
- Operational performance testing of CMS assembly.
- Environmental testing of CMS assembly (may be submitted as third party testing in submittal section C).

- Software functional testing of CMS assembly from local computer.
- Operational test for a continuous 24 hour period.

Request a Pre-Installation Test for one or more signs in writing a minimum of 30 calendar days in advance of the requested test session date. Permit the Engineer to adjust the proposed schedule of the Pre-Installation Test by up to seven (7) calendar days to allow for availability of Department representatives.

### H. Proof of Performance Testing

Submit a Proof of Performance Test Plan in accordance with this specification. The Proof of Performance Test Plan shall be a detailed and thorough procedure that fully demonstrates that the complete changeable message sign installation and all work required in the Plans and Specifications at that location meet all Contract requirements. Include with these requirements testing of the following items as a minimum:

- Verification of installation as per the Plans and Specifications, including construction, structural installation, guardrail installation, landscaping, grounding system, and utility installation
- Verification of identical components as installed to those used at the conclusion of pre-installation testing
- Operational performance testing of CMS assembly, including visibility testing, communications testing, display alignment, and workmanship items as per the Plans and Specifications
- Functional testing from local computer
- 48-hour operational testing

Request a Proof of Performance Test for one or more signs in writing a minimum of 15 calendar days in advance of the requested test session date. Permit the Engineer to adjust the proposed schedule of the Proof of Performance Test by up to seven (7) calendar days to allow for availability of Department representatives.

### I. Acceptance Testing

Submit an Acceptance Test Plan in accordance with this specification. The Acceptance Test Plan shall be a detailed and thorough procedure that fully demonstrates that the complete changeable message sign system and all work required in the Plans and Specifications meet all Contract requirements. Include in these requirements testing to demonstrate that all changeable message signs can be operated simultaneously as an integrated system. The Acceptance Test Plan shall include a method to verify that all operational items for each CMS can be controlled from a central control facility using the Department's NTCIP communication software and verified by field observation and status response messages.

Request an Acceptance Test in writing a minimum of 15 calendar days in advance of the requested test session date. Permit the Engineer to adjust the proposed schedule of the Acceptance Test by up to seven (7) calendar days to allow for availability of Department representatives.

### J. Burn-In Period

Request in writing to begin the burn-in period at least seven (7) calendar days in advance of requested burn-in commencement, but no less than 15 calendar days after successful completion of the following requirements:

- All CMS work required in all Contract documents (may be combined with construction contract) has been completed and inspected by the Engineer (except this burn-in period).
- All Acceptance Testing is successfully completed.

Furnish written reports to the Engineer of the nature, date, and time of all malfunctions, the nature of the repair or corrective action, and the description of any replaced components by equipment and the equipment serial and model numbers. Complete all corrective action within the time defined within these Specifications.

### K. CMS Support

Clearly identify in writing the designated contact person and alternate for support and warranty liaison with the Department. Failure to fully comply with the warranty and contractor support described in Subsection 631.3.07.A to the satisfaction of the Department shall be sufficient reason to disqualify the sign manufacturer from bidding on future CMS procurements.

### L. CMS Controller

Submit to the Construction Project Manager six copies of the Technical Specifications for the CMS controller unit as specified in Subsection 631.3.04.D. This submission shall include all information for the Department to determine the acceptability of the controller related to construction of the internal components, PCB construction, enclosure construction, power supply construction and capabilities, and operational characteristics and environments for construction and environmental tolerance of the CMS controller.

### M. Documentation

Provide three sets of documentation for all components in accordance with these Specifications. Assemble the documentation in volumes of 3-ring binders and include title pages, indexes, page numbering and section dividers.

The documentation shall consist of the following types of manuals:

1. User's Manuals

Describe in the User's Manual how to operate the particular type of equipment, layout of controls, displays, and all other information required to correctly operate a fully functional unit.

2. Operation and Maintenance Manuals

Provide an Operation and Maintenance Manual(s) for the CMS and for the CMS controller unit. Include in the manual(s) all the information required to maintain and repair the equipment to the component level. Provide sections which completely describe the theory of operation using block diagrams and schematic drawings, diagnostic and repair procedures for corrective maintenance of the unit; assembly and disassembly instructions and drawings, layout drawings showing location of all components; and complete components listing showing component type, ratings and acceptable manufacturers. Provide complete schematic diagrams to the component level. The Operation and Maintenance Manual shall fully describe all adjustments and alignment procedures and provide descriptions of expected signals at all test points and outputs. Provide a repair and troubleshooting decision tree that describes each function, a series of tests of each function, and an "if it does this, do that" process that defines faulty elements that require repair, replacement, or adjustment to restore operation of a malfunctioning sign or system element. Provide detailed operating specifications of equipment performance.

3. System Documentation Manual

The System Documentation Manual shall describe the overall operation of the equipment with block level diagrams. Identify all equipment in the system with module and option numbers. Give a functional description of each element of the system and explain how they function together in a complete system. Provide operating procedures describing the initial turn-on, adjustments to ensure that the system is operating within the performance requirements, and system level corrective maintenance procedures.

4. Software Manual

Documentation included within the Software Manual shall include descriptions and listings required to describe the complete operation of all software programs.

5. MIB Documentation Manual and Disk

Provide full documentation of the Management Information Base (MIB) that is used in the CMS controller. Specify the MIB in Abstract Syntax Notation 1 (ASN.1) format, and provide a copy of the MIB specified in ASN.1 in electronic format. The CMS controller must support mandatory objects as indicated by the Standard MIB. If the CMS controller does not support the full range of any object of the Standard MIB, then provide a custom MIB in ASN.1 format that specifies the supported ranges and includes meaningful description fields.

The manufacturer shall allow the use of any and all of this documentation by any party authorized by the Department for systems integration purposes or for use in NaviGAtor software at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

### N. Working Drawings

Submit working drawings to the Engineer no later than 30 calendar days after the Notice to Proceed. Include in the working drawings a pictorial representation of the assemblies that form a complete CMS system, the connection and wiring between assemblies, switch and adjustable control settings, and a description of the functionality of the assemblies including a listing of the assemblies required to form a complete CMS system.

### O. Training Material

Provide each training participant with a copy of course material. Include in course material copies of both a comprehensive manual and of the presentation material that will be used. Provide two (2) additional copies to the Department. Provide the classroom, audio-visual equipment, demonstration equipment and "hands-on" equipment required.

Provide a draft of the course material to the Engineer who will approve or reject the course material or content within three (3) weeks of receipt.

## 631.2 Materials

### A. General

Furnish only new equipment that conforms to the applicable requirements of the Underwriters Laboratory Incorporated (UL), the Electronic Industries Association (EIA), the National Electrical Code (NEC), the American Society of Testing and Materials (ASTM), the American National Standards Institute (ANSI), International Municipal Signal Association (IMSA), the National Electrical Manufacturers Association (NEMA), Rural Electrification Administration (REA), Illumination Engineers Society (IES), American Association of State Highway and Transportation Officials (AASHTO), American Welding Society (AWS), and the applicable Standards, Specifications, and Regulations of the Georgia Department of Transportation and to any other codes, standards, or ordinances which may apply. Whenever reference is made to any of the standards mentioned, consider the reference to mean the code, ordinance, or standard that is in effect at the time of the bid advertisement. Where conflicts occur between any of the Specifications defined above and this specification, this specification shall prevail.

### B. Components

1. General

Specific components used in any subassembly of the CMS shall be of the highest quality, industrial grade or MIL Spec. available consistent with the design of the equipment or subassembly.

2. Wiring, Cabling, and Harnesses

Ensure that all electrical conductors are stranded copper. Harnesses shall be properly bundled and tie-wrapped with external protection. Ensure that each harness is of adequate length to allow any conductor to be connected properly to its associated connector or termination point.

### C. Mechanical

1. Pin and Socket Connectors

Provide pin and socket connectors per IPC Standards..

### D. Laptop Computer

Provide a laptop computer for testing that will run the testing software as specified in Subsection 631.3.06.F. The laptop computer shall remain the property of the Contractor after the completion of all CMS testing.

### 631.2.02 Delivery, Storage and Handling

Not applicable

## 631.3 Construction Requirements

### 631.3.01 Personnel

Not applicable

### 631.3.02 Equipment

Not applicable

### 631.3.03 Preparation

Not applicable

### 631.3.04 Fabrication

**A. Components**

1. General

Use only electrical/electronic components that are of modular, interchangeable, plug-in type fabrication and are standard manufacturers' components and UL certified. The design shall be such that a single pixel driver board failure will not effect more than the light emitting modules directly controlled by the failed driver board. During replacement of defective driver boards or light emitting modules, ensure that the sign remains operational but need not display messages as defined within the failure modes described elsewhere in these Specifications.. All DMS shall have third party NEMA TS4 section 2 Environmental Testing.

2. LED Display Modules

The CMS shall contain LED display modules that include an LED pixel array and LED driver circuitry. These modules shall be mounted adjacent to one another in a two-dimensional array to form a continuous LED pixel matrix. Each LED display module shall be constructed as follows:

a. Each LED display module will consist of one circuit board. The header connections shall be constructed so that the boards cannot be connected incorrectly.

b. All LED modules shall be manufactured using laminated fiberglass printed circuit boards designed to IPC Standards.

c. Each LED display module shall be mounted to the rear of the display front face panel(s) using durable non-corrosive hardware. No tools shall be required for module removal and replacement. The modules shall be mounted such that the LEDs emit light through the face panels such that the face panel does not block any part of the viewing cone of any of the LEDs in the pixel. No light enhancing lenses shall be used to achieve viewing angles.

d. LED display module power and signal connections shall be q quick-disconnect locking connector type. Removal or replacement of a display module, or a pixel board or a driver circuit board from its display module shall not require soldering.

e. Removal or failure of any LED module shall not affect the operation of any other LED module or sign component. Removal of one or more LED modules shall not affect the structural integrity of any part of the sign.

f. It shall not be possible to mount an LED display module upside-down or in an otherwise incorrect position within the CMS display matrix.

g. All LED display modules, as well as the LED pixel boards and driver circuit boards, shall be identical and interchangeable throughout the CMS.

3. CMS LED Pixels

a. Each LED module shall contain a printed circuit board to which LED pixels are soldered. The LED pixel matrix shall confirm to the following requirements:

- Each LED module shall contain a minimum of 45 LED pixels configured in a two dimensional array. The pixel array shall be a minimum of nine (9) pixels high by five (5) pixels wide.
- For CMS Type 1, the distance from the center of one pixel to the center of all adjacent pixels, both horizontally and vertically, shall be 1.33 inches (34 mm). For CMS Type 2, 3 and 5 the distance from the center of one pixel to the center of all adjacent pixels, both horizontally and vertically, shall be 0.81 inches (20 mm). For CMS Type 4, displaying 12" characters, the pixel spacing shall be 1.75 inches (46 mm).
- Each pixel shall consist of a minimum of one (1) independent string of discrete LEDs for each color. All pixels shall contain an equal quantity of LED strings.
- The failure of an LED string or pixel shall not cause the failure of any other LED string or pixel in the CMS.
- Each pixel shall contain the quantity of discrete LEDs needed to output white colored light at a minimum luminous intensity of 12,400 candelas per square meter when measured using a photometric meter through the CMS front face panel assembly. Failure to conform to the requirements will be cause for rejection.
- Each pixel shall also be capable of displaying amber colored light with a minimum luminous intensity of 7,440 candelas per square meter when measured using a photometric meter through the CMS front face panel assembly. Failure to conform to the requirement shall be cause for rejection.
- The circular base of the discrete LEDs shall be soldered so that they are flush and parallel to the surface of the printed circuit board. The longitudinal axis of the LEDs shall be perpendicular to the circuit board.

b. Discrete LEDs - All LED shall have a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED. Viewing cone tolerances shall be as specified in the LED manufacturer's product specifications and shall not exceed +/- 5 degrees. The use of optical enhancing lenses to change the angle of viewing is not allowed and shall be cause for rejection.

- Red LEDs shall utilize Aluminum Indium Gallium Phosphide (AllinGaP) semiconductor technology and shall emit red light that has a peak wavelength of 615-635 nm
- Green LEDs shall utilize InGAN semiconductor technology and shall emit green light that has a peak wavelength of 520-535 nm
- Blue LEDs shall utilize InGaN semiconductor technology and shall emit blue light that has a peak wavelength of 464-470 nm
- The LED packages shall be fabricated from UV light resistant epoxy.
- The LED manufacturer shall assure color uniformity and consistency on the LED display face within the 30 degree cone of vision. Inconsistent color shifts or intensity will be cause for rejection.
- All LEDs used in all CMS provided for the contract for which this specification has been provided shall be from the same manufacturer and of the same part number, except for the variations in the part number for color and intensity.
- The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation under field conditions while maintaining a minimum of 50% of the original brightness. Field conditions shall include operating temperatures between -30 degrees F and + 165 degrees F (-34º and +74º C).

### B. Mechanical

1. Connectors

Verify that all connectors are keyed to prevent improper insertion of the wrong connector or PCB.

The mating connectors shall be designated by the connector number and male/female relationship such as CAP (plug or PCB edge connector) and CAS (socket).

2. PCB Assemblies

a. Design: Ensure that all assemblies are easily replaceable and incorporate plug-in capability for their associated devices or PCBs Use only silk screened PCBs that show all component locations and are identified as such by markings matching the drawings and schematics.

Permanently mark the manufacturer's name or logo, model number, serial number, and circuit issue or revision number on the PCB. Make all identification readily visible.

b. Workmanship: Perform all workmanship in accordance with the highest industry standards.

c. Hardware: Unless otherwise noted, use stainless steel hardware in electronic assemblies.

d. Printed Circuit Boards

**Definitions:** For the purpose of this subsection on PCBs, use design standards taken from ANSI/IPC-T-50, latest version/addendum.

PCB design shall be such that components may be removed and replaced without damage to boards, traces, tracks, or other components mounted on the board.

e. Soldering: Hand solder in compliance with Military Specification: MIL-PRF-31032, latest version/addendum.

Perform automatic flow soldering in accordance with EIA standards.

### C. CMS

This subsection describes the minimum requirements for the CMS assembly including the following major subassemblies:

- Sign housing and mounting hardware
- Sign face
- Display matrix
- Driving electronics
- Photosensor control
- Environmental control and protection
- Associated cables and wiring

1. Sign Housing

a. Design: Provide a CMS housing structural frame constructed with aluminum extrusions made from 6061-T6 and/or 6063-T6 aluminum alloy. The sign housing shall be constructed of 0.125-inch (3.17 mm) thick aluminum sheeting made from 5052-H32 aluminum alloy. Provide the CMS housing with a minimum of two lifting eyes to be used when placing the housing on the sign structure. Each lifting eye shall attach directly to the DMS housing structural frame and shall have sufficient structural strength to allow the sign to be lifted or moved without damage or deformation to any part of the sign. The sign housing shall be designed to allow mounting angles up to +/- 3 degrees from the vertical or, the front face of the CMS may be constructed with a permanent forward tilt angle of three(3) degrees, so that the top of the CMS housing is deeper than the bottom. The sign housing frame, exterior metal work, supporting structure attachment, catwalks, and lifting eyes assembly shall be certified by a Georgia registered structural engineer provided by the Contractor.

Use high strength aluminum alloy or stainless steel external mounting assembles (including clamps and all associated brackets) conforming to the diameter of the sign support truss beams. Provide all internal and external assembles with stainless steel bolts, washers and stainless steel nuts with nylon inserts. The clamping mechanisms shall be capable of mounting the sign on an overhead truss or bridge structure with an adjustment of the attachment angles. Adjustments to the position of the sign housing cannot require the removal of the housing from the supporting structure in order to align the housing into a different position.

The housing shall conform to the latest AASHTO publication entitled “Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals”. All sharp edges and corners shall be rounded.

Fabricate all CMS housings to present a clean, neat appearance. Protect the equipment located within the sign housing from moisture, dust, dirt, vehicle exhaust fumes, and corrosion.

Provide corrosion protection between dissimilar metals.

b. Welding: The CMS housing shall be welded and inspected in accordance with the requirements of *ANSI/AWS D1.2 Structural Welding Code-Aluminum*.

c. Housing Finish: All surfaces other than the front of the sign housing shall have a bare aluminum mill finish. All visible surfaces of the front face shall be entirely black except for the sign face perimeter strip. Include on the perimeter of the housing a 2 in. (50 mm) wide strip of retro-reflective fluorescent sign material; Amery Fasign (color: Chartreuse) or 3M Scotchcal (color: Saturn Yellow), or approved equivalent.

d. Housing Access: The housing shall be either walk-in or non-walk-in as identified on the Plans. For the non-walk-in housing, permit front access to modules, wiring, and internal components for maintenance purposes. Provide all walk-in housings with replaceable component access from the inside of the sign, excepting the sign face, and other miscellaneous items external to the sign housing.

e. CMS Platform and Housing Door: Provide all front access CMS signs with a suitable cat walk on the front of the sign housing. Include with all walk-in CMS sign housings a 4 ft. (1.2 m) wide or greater cat walk that extends from the right or left shoulder support structure, as defined in the plans, flush with or extending underneath the sign enclosure. Provide fold-down safety rails as a part of the catwalk. Provide a catwalk that will support at least 2,000 lbs. (907 kg) with no discernible displacement. All walk-in CMS sign housings shall provide for all display module and associated electronic and electrical maintenance, replacement, and field repair from the inside of the housing. External repair of the housing and sign face shall be the only items requiring access to the external portions of the housing.

Provide walk-in housings with a minimum 2.5 ft. (0.76 m) by 6 ft. (1.8 m) opening that is dust and moisture tight, lockable, with external and internal stainless steel lever handled door latch system. Ensure that the door latch system can be locked, unlocked, opened, or closed from either the outside or inside of the housing. Ensure that the door latch system does not require a key to lock, unlock, or open the door from the inside of the housing. The outside lock shall be a swing cover, plated brass, tumbler type that is designed for outdoor “no freeze up” applications. Use a No. 2 Corbin key. Provide hold open braces and door stops that allow the door to be held in the full, 90, 45, or 30 degree open positions without the use of tools. Use hold open braces, doors, and hinges designed to withstand a minimum of 40 MPH (64 km/hr) winds while the door is held in any of these positions.

Provide walk-in housings with lighting and duplex receptacles: On the interior of the walk-in sign housing, provide a circuit breaker protected, shielded, fluorescent lighting system to allow maintenance personnel ample working light during day or night maintenance or repair conditions. Activate the light by a timer switch located on the inside of the housing near the door. The light switch timer shall begin timing a “lights on” condition of two hours upon activation of the switch. Turning the switch off and back on will reset the time out to another two hours from the time of the off-on cycle of the switch. Upon time out of the two hour period, the switch shall deactivate the fluorescent lighting by disconnecting the 120 VAC ungrounded circuit from the light. Use a circuit breaker to protect two separate duplex 120V ground fault interrupter (GFI) receptacles that are provided on each end of the sign case for the use of maintenance personnel. Use receptacles rated for 15 amperes. Each receptacle shall be fed from a 15 ampere nominal 120 VAC circuit.

f. CMS Weight and Dimension: Total weight, including all internal and external components for walk-in signs, cannot exceed 3400 lbs. (1542 kg) for signs fifteen characters wide or less and 4100 lbs. (1859 kg) for signs greater than fifteen characters wide.

Individually limit the maximum outside dimensions, excluding minor appurtenances, of the sign to the following.

- Width 31 feet (9.44 m)
- Height 10 feet (3.3 m)
- Depth 4.5 feet (1.4 m)

Limit the power consumption to 4000 watts for signs fifteen characters wide or less and 6000 watts for the signs greater than fifteen characters wide, with all pixels, fans, heaters, and auxiliary equipment operating at their maximum output setting.

g. Hardware Material: Use stainless steel hardware unless otherwise specified. Use nylon friction washers.

h. Maintenance Safety Tie-offs or Anchor Points: Supply the sign with OSHA compliant anchor eyebolts for the connection of a personal fall arrest system. These anchorages must be strong enough to withstand a force of 5,000 pounds (22.2 kilonewtons) as required by OSHA. The anchorages must be located such that they will not allow a person to free-fall more than 6 feet when a 6 foot lifeline is used.

2. Sign Face

The front face of the CMS shall be constructed with multiple rigid panels, each of which supports and protects a full-height section of the LED display matrix. The panels shall be fabricated aluminum sheeting on the exterior and polycarbonate sheeting on the interior of the panel. The aluminum mask of each panel shall contain openings for each pixel that are large enough to not block any portion of the viewing cones of the LEDs.

The front face panels (and the borders of the front face of the sign) shall be coated with semi-gloss black Kynar 500 resin or equal, which has an expected outdoor service life of 10 to 15 years.

The sign face panels shall be attached to each other using stainless steel hardware. Seams separating the panels shall be sealed. The panels shall be mounted in a way so that they are removable from the interior of the sign for walk-in structures and from the outside of the sign for front access signs. The panels shall not be welded or otherwise permanently mounted to the CMS housing.

Each face panel shall have a single polycarbonate sheet attached securely to the inside of the aluminum panel to cover and seal the face to prevent water and other elements from entering the sign. The polycarbonate shall contain UV inhibitors that prevent premature aging of the material and to protect the LED display matrix from the effects of ultraviolet light exposure. A plastic lens system to replace the polycarbonate sheet is not acceptable.

The LED display modules shall mount to the inside of the DMS front face panels.

3. Display Matrix

a. Spacing: The CMS shall contain a full display matrix with the rows and columns of pixels as described in this specification for the sign type specified in the plans. The matrix shall display messages that are continuous, uniform, and unbroken in appearance to the motorists using the roadway approaching the sign location. For sign types 1, 2 and 3, the pixel matrix shall be capable of displaying alphanumeric 18” (460mm) high characters in accordance with the definition defined by NEMA TS 4 Hardware Standards for Dynamic Message Signs Standards. For Type 4 and 5 signs, the pixel matrix shall be capable of displaying alphanumeric 12” (308mm) high characters. The CMS shall be able to display messages composed of an combination of alphanumeric text, punctuation symbols, and graphic images across multiple frames. Each display pixel shall be composed of multiple red, green and blue LEDs. Other pixel technologies shall not be accepted.

b. Display Visibility: Ensure that the sign display is clearly visible and legible from distances between 150 ft. (45.7 m) and 1,100 ft. (335 m) from the CMS display face under normal freeway operating conditions. Sign luminous intensity at testing shall be 12,400 candelas per square meter minimum (white) for full color displays. Verify the luminous intensity of the pixel will not decrease more than 50 percent when viewed at an angle of ±15 degrees when centered about the optical axis and perpendicular to the surface of the display.

4. Pixel Drive Circuitry

Electronic driver circuitry shall be provided for each LED pixel module and shall individually control all pixels on that module. The driver circuit boards shall meet the following requirements:

- Each LED driver board shall be microprocessor controlled and shall communicate with the sign controller on a wire or fiber optic communications network using an addressable network protocol. The microprocessor shall process commands from the sign controller to display data, perform diagnostics, and report pixel and diagnostic status.
- Constant current LED driver ICs shall be used to prevent LED forward current from exceeding the LED manufacturer’s recommended forward current whenever a forward voltage is applied. To maximize LED service

life, LED drive currents will not be allowed that exceed the manufacturer's recommendations for the 100.000 hour lifetime requirement.

- The LED pixels shall be directly driven using pulse width modulation (PWM) of the drive current to control the display intensity. This LED driver circuitry shall vary the current pulse width to achieve the proper display intensity levels for all ambient light conditions. The drive current pulse shall be modulated at a frequency high enough to provide flicker-free operation and a minimum of 200 brightness levels.
- The LED driver circuitry shall receive updated display data at a minimum rate of one (1) frame per second from the sign controller.
- Each LED driver circuit shall be powered by 24 VDC from external regulated DC power supplies. Each driver circuit shall receive power from a minimum of two (2) independent power supplies to provide redundancy. Indicator LEDs shall indicate the status of each power source.
- The voltage of each power input shall be measured to the nearest tenth of a volt and reported to the sign controller upon request. Each driver circuit shall also contain one status LED for each power source that indicates if the power source is present or not.
- The LED driver circuitry shall be able to detect that individual LED strings or pixels are stuck off and shall report the pixel status to the sign controller.
- The LED driver board shall contain an indicator showing the functional status of the LED pixel display module. At a minimum, it shall indicate error states of the LED pixels and communication network. The indicator shall be positioned so that a maintenance technician can easily view the status code for diagnostic purposes. The LED display module shall report the status, including pixel errors, voltage levels, etc. to the sign controller.

5. DC Power Supplies

Provide auto-ranging regulated DC power supplies for the LED pixel display modules that convert the incoming AC to DC at a nominal voltage of 24 volts DC. Power supplies shall be arranged in redundant pairs, wired in parallel configuration that uses multiple supplies for the CMS display matrix. The power supplies shall meet the following requirements:

- Power supplies shall be rated such that if one supply fails, the remaining supply shall be able to operate 100% of the pixels in that display region at 100% brightness .
- The power supply shall be sufficiently sized to maintain the appropriate LED display intensity throughout the entire operating input voltage range.
- The power supply output shall be connected to multiple circuits that provide power to the LED modules. Each output circuit shall not exceed 15 amperes and shall be fused.
- Power supplies shall be monitored by a microprocessor-controlled circuit. This circuit shall monitor the voltage of each power supply and the status of each output circuit's fuse. The power supply voltages and fuse state shall be reported via a controller communication area network to the sign controller upon request.
- The power supplies used to power the LED pixel modules must be identical and interchangeable throughout the CMS.
- The power supplies must be UL listed.
- The power supplies shall provide a nominal output voltage of 24VDC +/- 10% with a nominal maximum output power rating of 1000 watts, with an operating input voltage range of a minimum of 90 to 260 VAC.
- Each power supply shall automatically shut down and restart if the power supply overheats or an output fault occurs for over-voltage, over current or short circuit.

6. Ambient Light Measurement

Provide a changeable message sign with electronic light sensors. These devices shall permit automatic light intensity measurement of light conditions at each sign location. The sensors shall be mounted in a manner to measure front, rear and ambient light conditions.

The sensors shall be internally read by the CMS dimming system. The CMS sign controller shall continuously monitor the light sensors and adjust the LED display matrix intensity to a level that creates a legible message on the CMS face.

7. Environmental Control and Protection

a. The CMS shall be equipped with a minimum of one (1) ambient temperature sensor, one (1) internal temperature sensor and one (1) sensor that measures the relative humidity of the air inside the CMS housing. The external temperature sensor shall be placed and mounted such that it is never in direct sunlight. The internal temperature sensor shall be mounted in a well ventilated location inside the structure, easily accessible for maintenance and verification of accuracy. The relative humidity sensor shall be similarly mounted. All sensors shall report data to the CMS control software and be used to control systems for cabinet ventilation, sign face panel fog and frost prevention, and safe over-temperature shutdown.

b. Ventilation System: Provide the CMS housing with the necessary louvered vents positioned such that vehicle exhaust fume intrusion into the sign housing is minimized while the housing is provided with sufficient ventilation to maintain the thermostat temperature settings. Provide fans to positively pressure the CMS cabinet enclosure, thermostatically and parallel timer switch controlled, to keep the internal CMS air temperature lower than 140 °F (60 °C) when an outdoor ambient temperature is 115 °F (46 °C) or less..

   Provide an Over Temperature Safety Shutdown to automatically shut down the LED modules if the measured internal CMS air temperature exceeds a maximum threshold temperature. The threshold temperature shall be configurable and have a default setting of 140º F (60º C) .

   Each intake port shall be equipped with air filters that remove airborne particles measuring 500 microns in diameter and larger. Use replaceable dust filters across all vents and position them such that when in place a secure dust tight joint exists between the filter and the housing. Install fans in protected fan openings within the CMS housing such that moisture, dust, vehicle exhaust fumes, or insects or birds will not enter the fan opening. Walk-in signs shall have fans and air filters that are removable and replaceable from inside the CMS housing. A monitoring system shall be provided to report the fan(s) operation to the sign controller upon request.

   Provide an override timer switch for manual operation of the fans by maintenance personnel that, when placed in the on position will turn on the fans for a period of from zero (0) to four (4) hours.

   Provide an automatically controlled defog system that warms the CMS front face when the internal CMS relative humidity is near condensation levels. This system shall keep the front face polycarbonate panel free of fog and condensation.

8. Associated Cables and Wiring

Controller-to-Sign Interface cables shall be fiber-optic signal cable per manufacturer specifications or optionally, may be copper signal cable, CAT 5 cable with RJ45 connectors.

Protect all electrical cables against lightning or over-voltage conditions with appropriate surge protectors. Mount surge protection units in such a manner that component testing is not impaired and the replacement of components is easily accomplished without the removal of other components.

Ensure that grounding wire and connectors meet the requirements of the appropriate electrical codes and the applicable sections of GDOT Supplemental Specification 925.

### D. CMS Controller

Each CMS shall be controlled and monitored by a CMS controller. This controller will be housed in a base mounted cabinet remotely located from the CMS structure so that diagnostics and maintenance may be performed at the cabinet while viewing the sign face.

1. General

The sign controller shall meet the following requirements:

- Shall communicate using embedded NTCIP protocol..
- NEMA TS 4 compliant
- Contains memory for storing custom and permanent messages, schedules and other files necessary for controller operation.
- Shall include a front panel user interface with graphical LCD and keypad for direct operation and diagnostics of the CMS.
- Provide a watchdog timer for detecting controller failure and resetting the microprocessor.
- Includes functions such as plan storage and communications with the CMS central control facility software which will be conducted by software resident in the controller unit.
- The unit shall be capable of providing electrical isolation, monitoring of sign status, detection of failed elements and other features particular to the sign design
- The CMS controller unit shall operate from a nominal 120 VAC, 60 Hz power supply. The power consumption of the CMS controller unit, power supply and permanently connected equipment cannot exceed 250 watts total.

Include with the CMS controller unit a power on/off switch that controls the AC power to the controller unit. Mount the switch on the front face of the enclosure and mechanically protect it from accidental shut off.

Provide a CMS controller unit and its associated software that meet all of the functional requirements of the CMS Specification and fully support the NTCIP protocol stack.

2. Communications

a. CMS Controller

Provide the CMS controller unit with a 100Base-TX or 10Base-TX Ethernet port to allow connections between the controller and the CMS central control facility or hub via the field communications system. This communication port shall be configured as MDI. This communication port shall use standard RJ-45 female connector.

Provide the CMS controller unit with a second communication port. This second port shall be an EIA 232-C serial communication port to allow connections between the controller and a laptop computer. This communication port shall be located on the front of the CMS controller enclosure and it shall be configured as DCE. This communication port shall use a 25-pin socket connector (ITT DB-25S or equivalent). The communication port shall support dial-up modems, spread spectrum radio modems, cellular phone data port connections, fiber optic modems, and other communication devices that are compliant with the RS-232 standard.

Provide the CMS controller unit with a fiber optic channel connection to allow connections between the controller and the changeable message sign. This communication port shall be compatible with the sign communication port.

Provide a communication timer within each CMS controller for detecting failure of communications with the CMS central control facility. The timeout value shall be selectable between one (1) and sixty (60) minutes with one-minute resolution. The timeout shall be capable of keypad and laptop commanded disabling for use during periods of dialup or similar communication service where a periodic poll of the CMS within the 1 to 60 minute period is not normally made. The default shall be the last selection made of either timeout or non-timeout.

3. Functionality

The functionality of the CMS is defined by the NTCIP protocol stack that has been defined for the CMS controller and the collection of data objects that exist in the MIB of the device. The following list constitutes an overview of the normal mode of operation of the CMS system. Normal mode of operation is defined as the state in which the controller is communicating with the CMS central control facility and processing requests from the central control facility. The major function of the controller is to change the message displayed at the CMS. Secondary functions of the controller may include the following: responding to status requests from the central control facility, storing new messages that have been sent to the controller from

the central control facility, sending configuration data to or receiving and updating configuration data from the central control facility, and sending the currently displayed message to the central control facility. During normal operation, the controller unit will expect at least one successfully communicated message during a specified time period from the central control facility; a configurable master communication timer controls this time period. If no message is received, the controller unit shall take over in its communication loss mode. Furthermore, upon receipt of a message, the CMS controller shall respond to the message within five (5) seconds. Should the controller fail to respond within this time period, the entity that generated the request will assume that the request has failed.

a. Data Objects for Controllers: The SNMP Application Level protocol shall be used to access all of the data objects that have been defined at the Information Level of the NTCIP protocol stack. The value of some data objects may be updated, and the value of all data objects may be retrieved. The control mode of the CMS controller shall affect the accessibility of these objects, and a discussion of the various control modes has been given below.

b. Dwell Time: Dwell time is the time required for displaying and blanking the sign (or part of the sign for two phase signs) and for flashing or blinking lines and symbols (or parts of lines). Dwell times shall be in units of tenths of a second and shall range from 0 to 5 seconds. Various MULTI tags and default values provide this functionality.

c. Maximum Response Time: The Maximum Response Time defines the maximum amount of time that the CMS controller can take to respond to a particular SNMP or STMP request. The Maximum Response Time for the CMS controller shall be five (5) seconds. Should the controller fail to respond within this time period, the entity that generated the request shall assume that the request has failed.

d. Master Communication Timer: The master communication timer keeps the time that has elapsed since the CMS local controller received a correctly formed SNMP or STMP request from the central control system, and it resets upon each request. The timer shall be in units of minutes, shall range from 1 to 60 minutes, and shall have a default value of 10 minutes.

e. CMS Default Messages: Store two default messages in non-volatile memory. The stored default messages shall be used when there is a communication loss between the controller and the central control facility or when the CMS controller unit reboots after a power failure. The default message selected will be a result of the failure type.

f. Blank Time: Blank time is the length of time the sign is blanked between changes in message display. Blank times shall be in units of tenths of a second and shall range from 0 to 10 seconds. Various MULTI tags and default values provide this functionality.

g. The CMS controller shall store two (2) default fonts for use in message display. The CMS controller shall be capable of storing four (4) graphic images and displaying one of these images at a time on the CMS.

   The CMS controller unit shall be capable of displaying the longest possible one-phase message within two (2) seconds of the receipt of the complete SNMP or STMP request.

   Messages shall be specified in the MULTI syntax. The presence of a tag in the message string shall override the default value that has been set if such a default has been configured. The following MULTI tags shall be supported:

   - Field
   - Flash
   - Font
   - Justification – Line
   - Justification – Page
   - Moving Text
   - New Line
   - New Page
   - Page Time

h. Controller States: A CMS can be in various states prior to the commands, which may affect how these functions are performed. These modes are:

*Power Loss Mode*: This mode is reached when power has been lost to the CMS controller, and it has switched to its backup power source. If this mode is reached, then the controller shall display the default message that pertains to power loss if this message has been set.

*Communication Loss Mode*: This mode is reached after a communication timeout has occurred which may be a result of the central control facility being offline or a disruption of the communication channel. If this mode is reached, then the controller shall display the default message that pertains to communications loss if this message has been set, and the master communication timer shall be disabled.

*Local Mode:* This mode is reached when the CMS controller unit has been put under manual control in the field. Any SNMP or STMP update requests received from the central control facility shall be ignored.

*Central Mode:* This mode represents the normal operation of the CMS controller. On a user selectable time basis, the central control facility software shall poll the controller unit for status to receive any failure or recovery information.

*Central Override Mode:* This mode can be used to override a CMS controller that has been placed in Local Mode.

i. Controller State Changes: The central control facility can change the operational state of the CMS controller. The Central control facility can send a local mode off command to the CMS controller unit.

The CMS controller shall be able to be put into Local Mode by field personnel at the CMS and shall be able to be controlled by the controller keypad or a laptop computer that has been attached to one of the serial interfaces. The message displayed on the sign shall not change when the CMS controller unit mode is changed to Local Mode. A CMS controller that has been switched into Local Mode shall ignore requests from the central control facility. The central control facility can override Local Mode by changing the operational state of the CMS controller to Central Override Mode.

j. Diagnostic Functions: Diagnostic functions shall allow the user to diagnose errors on a CMS controller unit. Ensure that the central control facility or a laptop computer is able to command the following:

*Software Reset:* Ensure that the reset request will cause the CMS controller unit to restart the control program . This is similar to a complete bootstrap of the CMS controller unit and shall be non-destructive of library messages stored in volatile memory. The following steps shall make up the reset process:

- Any temporary variables and the message displayed on the CMS shall be lost as the control program restarts and reinitializes such variables. The CRC of each message stored in the memory of the controller shall be recalculated and compared with the stored value. If the CRC comparison for a particular message fails, then the message shall be invalidated, and that storage slot shall be made available.
- If a default message has been defined for a reset, then it shall be displayed; otherwise, the sign shall be blanked.

*Test Pattern:* On command, the CMS controller shall display a test pattern on the CMS. The test patterns shall cycle through turning banks of display elements on and off. The pixels shall remain in each particular pattern for sufficient time for a user to validate the pattern. The requirement of this test pattern is to exercise each display element and allow the validation of the operation of all display elements. The preferred test pattern consists of a "checkerboard" of alternating modules that are on or off for a length of time and then reverse their polarity. Other test patterns of similar function, but not distractive to motorists, may be used subject to the approval of the Engineer.

*Blank the CMS:* On command, the CMS controller shall change all the display elements to the off position. The CMS display shall stay in this format until the next display command is received.

*CMS Element Status:* On command the CMS controller shall exercise the full diagnostics of the CMS including a report of any failed elements, condition bits set (e.g., power off, comm. failure, reset), etc.

*Configuration Parameter Retrieval:* On command, the CMS controller shall return the value of a particular parameter.

*Message Retrieval:* On command, the CMS controller shall return a particular message from its storage.

k. Regular Checks by the CMS Controller

*Message Library*: Each individual messages shall have a CRC stored with it when it is downloaded. The CMS controller unit shall recalculate the CRC of a particular message and compare it with the value stored whenever it attempts to display that message. Any difference shall cause a library error to be stored for reporting to the central control facility.

*Failed Display Elements*: The CMS controller unit shall verify all display elements on a regular basis. The CMS shall detect and report any display elements that are not controllable. Whenever a message is displayed, all elements that are to be enabled shall be checked immediately after the display is completed.

*Major Component Checks*: The CMS controller unit shall monitor the major components of the sign such as power supplies, pixels, the controller, light sensors, fans, or temperature sensors. If any of these components fail or become uncontrollable, the CMS controller unit shall record this for reporting to the central control facility. This monitoring shall be on each change of message displayed and at regular intervals.

*Watchdog*: The CMS controller unit shall keep a hardware watchdog on the sign's own operation. During normal processing, the processor shall reset this watchdog every few seconds. If this watchdog is not reset for a period, there shall be a hardware switch that will reset the CMS controller.

*Controller Bootstrap*: During the bootstrap process, the CMS controller unit (usually after a power failure) shall carry out the following steps:

- Any temporary variables, and the message displayed on the CMS, shall be reset as the control program starts and reinitializes such variables.
- The CMS controller unit shall recalculate the CRC of each message in its storage and compare it with the corresponding stored value.
- If a default message has been defined for a controller boot, then it shall be displayed; otherwise, the sign shall be blanked.

l. Controller Keypad: Provide a keypad on the controller face to input programming and CMS configuration data. The keypad shall allow full access to the CMS operating parameters and commands. A laptop computer or central computer system cannot be required to set up or operate the CMS.

m. Control of Sign Luminance

*Illumination Control*: The CMS controller shall provide multiple levels of illumination control.

- Light Sensor Control: The luminance level of the CMS shall be determined by the values of light sensors that are attached to the CMS.
- Manual Control: The luminance level of the CMS shall be determined by the value set by the central control agency

*Luminance Levels*: The luminance of a light emitting pixel shall have a minimum of three levels selected in accordance with the ambient illumination level as read by the light sensor system and the software control . Typical ranges are:

- overbright range, level 3
- daylight range, level 2
- night range, level 1

Equip the CMS controller unit with dimming circuitry that will allow selection of the light intensity levels for each range to best suit the sign location. The dimming scheme used cannot reduce the rated life of the light source. There can be no observable flicker or difference in consistency between pixels at any of the intensity ranges.

Incorporate sufficient hysteresis in the sensor or control circuit to ensure that no rapid or erratic changes are implemented when the environmental lighting level fluctuates around the threshold .

*Sensor Failure:* In case of sensor system failure, the light output of the sign display elements shall be defaulted to the night range setting.

### E. CMS Controller Cabinet

The cabinet shall house all of the CMS equipment required to control, monitor, and communicate to the CMS and all of the equipment required to communicate with the communications hub or central facility as shown on the Plans. Include with the

equipment housed within the cabinet, as a minimum, the rack mounted CMS controller unit, the communication interface between the CMS and the CMS controller, the interface between the CMS controller and the fiber optic communication equipment and interconnection panel, the laptop computer interface, all power supplies and power termination and distribution equipment, all wiring, cables and jumpers, and all environmental protection material and equipment.

Provide the CMS controller cabinet with the necessary louvered vents positioned such that vehicle exhaust fume intrusion into the cabinet is minimized while the housing is provided with sufficient ventilation to maintain the thermostat temperature settings. Provide fans, thermostatically and parallel timer switch controlled, to pull warm air out of the cabinet to support the venting of the heat within the cabinet to the extent that an interior temperature of no more than 130 ºF (54 ºC) is reached with a 120 ºF (49 ºC) direct sunlight generated ambient temperature with the cabinet door closed and locked.

Use replaceable waterproof washable dust filters across all vents and position them such that when in place a secure dust tight joint exists between the filter and the cabinet. Install fans in protected fan openings within the cabinet such that moisture, dust, vehicle exhaust fumes, or insects or birds will not enter the fan opening.

Control the ventilation fan(s) by thermostat adjustable to operate the fan(s) between the range of 70 ºF to 130 ºF (20 ºC to 54 ºC). The on-off temperature delta of the thermostat shall be nominally 3 ºF (1.7 ºC). Verify that the current rating of the thermostat is no less than 200 percent of the respective controlled equipment. Install Quencharc or other suitable devices across the thermostat and switch contacts that will prevent electromagnetic interference being generated with the opening or closing of the thermostat contacts under electrical load.

Identify different components of the controller equipment including all the wires, connectors, control leads, switches, etc., with labels of engraved lamanoid or with permanent transfers. The identifiers shall correspond to the labels used in the equipment documentation and maintenance material.

Mount all protective devices such as lightning arrestors and surge protectors external to the CMS controller unit enclosure.

Provide FDC, Sliding Drawer, Field Switch, and Power panel.

All mounting hardware and wire connections shall be easily accessible and removable with hand tools.

Ensure that the driver circuitry installed in the controller cabinet meets or exceeds the electrical and environmental specifications of the CMS.

### F. Interconnection Cables

1. Power Cables

Use bundled multi-conductor power cables connecting 120 volt circuits between the CMS controller unit and the CMS housing equipment power distribution area. Size the power cables as required by the load and distance.

2. Signal or Communications Cables

Use bundled, shielded, jacketed multi-conductor signal or communications cables to connect circuits of 50 volts or less (including fiber optic cable) between the CMS controller unit and the CMS housing. Size the cables as required by load and distance. If a parallel (non-multiplexed) means of interconnection is used between the controller unit and the sign, carry out tests approved by the Engineer to ensure that no significant signal deterioration occurs. Design the communication channels for acceptable noise margin limits specified by the logic family or drivers/receivers used.

Fiber optic cable may be used for the sign controller signal interface from either ground mounted or pole mounted cabinets.

3. Protective Devices

Provide all electrical cables entering the cabinet with surge protective devices installed inside the controller cabinet equal to or exceeding the requirements of GDOT Specification Section 925. The protective devices shall be encapsulated hybrid suppressers and shall be bayonet mounted such that replacement can be done without removal of the housing or other equipment.

## 631.3.05 Construction

### A. General Requirements

Establish the electrical power service required for a CMS installation as described in Section 939.

### B. Wiring, Cabling and Harnesses

Make all harnesses neat and firm, and route them to minimize crosstalk and electrical interference.

Separately bundle or shield wiring containing AC from all DC logic control circuits.

Route wiring to prevent conductors from being in contact with metal edges. Arrange wiring so that any removable assembly may be removed without disturbing conductors not associated with that assembly.

Install all wiring as a part of the CMS assembly and controller including power, communication, and fiber optic control cables between cables necessary to operate the changeable message signs. Install the cables in liquid tight conduit in inconspicuous locations, between the nipples on the sign support and the housing. Install the cables to use the sign support beams and legs as raceways and install them in continuous, un-spliced lengths between the housing and the CMS controller cabinet unit. Coil sufficient slack neatly in the base of the CMS controller cabinet to ensure that the connections to the housing and the power source will be possible without the need to add or splice any cables. At vertical transitions, support the cable by integral hooks or other methods that assure that the stress placed on the wiring or fiber optic cable is minimized and in no case violates the cable or wire manufacturers maximum static, pulling, or dynamic tension, or bend radius.

Route all wiring within the sign in properly supported cable trays.

### C. CMS

1. General

The following section provides a description of a permanent changeable message sign (CMS) assembly. Ensure that the various subassemblies are interchangeable between the same type of sign and 100 percent compatible with NTCIP protocol stack.

2. Timing of Work

Ensure that CMS controller units are installed, tested, and ready for operation before installing the changeable message signs. Do not install changeable message signs until 14 calendar days or less, prior to beginning the proof of performance testing. Install the CMS during restricted times, as designated by the Department, and control all traffic using the GDOT approved pacing method. Proceed with installation only upon approval of the pre-installation tests results. Notify the Engineer 96 hours prior to installation.

3. Installation

Maintain full responsibility for the sign housing mounting to the support structure and confirm that the sign can be properly mounted on the sign support structure prior to installation. Provide complete structural shop drawings and calculations of the sign mounting to the support structure to the Department as part of the submittal data requirements in Section 631.1.03. Securely mount the sign on the sign support structure. Initially set the housing at a 3 degree tilt **forward** toward traffic and adjust the housing under both day and night conditions to optimize the view of the sign from the roadway by a motorist and eliminate random reflections as directed by the Engineer. Alternatively, the housing may be constructed at a 3 degree tilt toward traffic, if approved by the Engineer, but shall be adjusted to obtain the same optimization of the viewing of the sign from the roadway.

Signs mounted on roadside supports shall be angled toward the roadway by 7 degrees to maximize the viewing angle for motorists.

Attach and secure all mechanical hardware for initial attachment prior to the reopening of lanes to traffic. Complete attachment of hardware prior to the release of crane cables. Install and connect the CMS sign wiring and communications cables to the ground cabinet and disconnect switch in the controller cabinet only after attaching and securing the sign to the sign structure. During the proof of performance testing, the Engineer will evaluate the initial setting of the sign and direct the

Contractor to adjust the sign tilt if necessary. Use nylon stop washers with mounting attachments. For all structural aspects, stainless lock washers and nuts are unacceptable; use stainless steel nuts with nylon inserts for locking.

Lift and install the CMS housing and display in place on the overhead structure only with prior approval of, and in the presence of the Engineer. Do not lift and install the CMS housing and display until all equipment, materials, and labor are available such that the CMS can be operated with messages from the local CMS controller within 72 hours of installation on the overhead structure. Program message displays on the CMS at the direction of the Engineer. Make sight alignment adjustments to the CMS housing and display as directed by the Engineer.

Securely install mounting hardware to the torque recommended by the overhead sign support manufacturer.

4. Controller Unit to CMS Interconnection

Install all interconnecting cables between the equipment in the CMS controller cabinet and the sign inside two (2) 2" (50.8 mm) diameter ducts, which are installed between the sign footing and the concrete pad of the controller cabinet. If additional 2" (50.8 mm) ducts are required to accommodate the sign manufacturers interconnect requirements, add additional ducts in multiples of two (2) each, 2" (50.8 mm) ducts. Provide all communications between the ground mounted CMS controller cabinet and the above ground mounted sign in the form of fiber optic cable and signaling.

5. Cabinet Equipment

a. Wiring and Connections: Make all connections to terminal boards or screw-type equipment terminals with insulated fork-tongue compression connectors only when using stranded cable. Make all wiring to bulkhead connectors on equipment housings with MS bayonet-type connectors. Solder connector joints for use with extra-low voltage systems, with the joint metals preheated to the flow temperature of the solder or crimped using ratchet-type positive crimp tools and a double crimp (conductor and jacket) connector.

   Remove the outer jacket of data and communications cables to expose approximately 6 in. (150 mm) of the shielding or drain wire. Twist together and solder the shielding or drain wire for all cables serving a similar function with a #10 AWG minimum insulated (green) ground lead securely connected to the cabinet ground bus. Make the ground lead routing as short as possible. Cut the shield off and leave it isolated at the other end.

   Upon completion of wiring and connections, bundle all incoming cables and hold in place with nylon cable ties. Connect the front panel and chassis to the cabinet ground bus from a single point only.

   The controller will be powered from the power distribution assembly provided in the field cabinet. Bond the shields of all extra-low voltage cables to the ground bus inside the cabinet. The shield inside the sign enclosure shall be unconnected and insulated. Route low voltage cables and extra-low voltage cables installed in the cabinet on opposite sides of the cabinet. Group similar extra-low voltage cables in the controller cabinets, between common locations, together with cable ties. Install cables and connectors so that the manufacturer's rated minimum bending radius and pulling tension are not exceeded. Take proper care to prevent abrasions to the cable jacket during installation.

b. Controller Cabinet Installation: Install the CMS controller unit in the designated space of the field cabinet. Install the cabinet at locations as indicated on the Contract drawings or as designated by the Engineer. Mount all cabinet assemblies to the support pole at a height of 4 ft +/- 3 in (1.2 m +/- 76 mm) from ground level to the centerline of the cabinet housing. Where the Plans show base-mounted cabinets, install the cabinets in accordance with the Department’s Standard Specification for Traffic Signal Equipment installations.

6. Light Sensor System

Adjust the light sensor(s) and calibrate the dimming system consistent with field conditions found for each sign as a part of the installation process. Perform this work prior to any proof of performance acceptance test.

7. Support Material

Test the support material components specified in Subsection 631.4.A as per the appropriate pre-installation procedures as defined in the Specifications. Deliver the components prior to final acceptance of the Contract and beginning of the CMS support period.

## 631.3.06 Quality Acceptance

### A. Use and Operations Prior To Final Acceptance

The Department will approve or control any and all CMS displays at all times that a display is in potential public view. When potential public view exists, no message or graphical display of any kind or activation of any CMS display component is permitted without prior approval of the Engineer. At such time as the Engineer determines that any given CMS is ready for Department control, the Department will exercise complete and total control of that CMS display and all central and local communications with that local CMS controller. Prior to any action, coordinate with the Engineer any remaining work or any testing or maintenance that may affect that CMS display. Do not interpret such CMS display control as acceptance of the project in whole or in part. Do not construe such action as a waiver by the Engineer of any provision of this Specification. Do not consider such use part of the burn-in period.

### B. Utility Coordination

Establish the electrical power service required for a CMS installation as described in Section 939.

This Specification includes provisions whereby the Contractor furnishes or installs equipment and materials that will become part of the regional utility facility. Coordinate all such work with the utility representatives, and furnish all equipment and materials and perform all work in accordance with the Contract Documents and all applicable utility agency standards and procedures.

Meet all standards required by utility companies as related to CMS equipment, materials, and installation associated with attachment to related power service feeds or leased communication connections. Test the power and telephone utility service to confirm proper voltage and current capacity and the serviceability of any telephone circuit connected to CMS equipment.

Power utility or telephone utility representatives are not authorized to revoke, alter, or waive any requirements or design of materials or facilities provided under this Specification. The inspection of any of the Contractor's work by the utility providers or the failure to inspect any of the Contractor's work by the utility provider representatives will not relieve the Contractor of any requirements of this Specification.

Coordinate work with the utility providers to permit inspection of said work. Notify the Engineer and the utility providers' representatives of planned work.

### C. Control of Work

Maintain all work under this Contract from the date of award of Contract to the date of final acceptance of the project by the Engineer. Maintain responsibility for making all trouble calls, diagnosis, repair, and replacement, supplying all equipment and materials; providing maintenance of traffic, and performing any other work necessary to maintain all work as required above. Within one (1) hour of notice from the Engineer or after other identification of a problem, make an on-site trouble call. Complete all work necessary to correct the problem within twenty-four (24) hours unless otherwise directed by the Engineer. Within 48 hours of having completed a trouble call or repair, provide a written report to the Engineer fully describing the problem, its cause, all action taken, and all equipment and materials repaired or replaced.

The Department will not be liable for any equipment or material purchased, work done, or delay incurred, prior to the Department's approval of said equipment or material through the materials submittal data process. Any failure of the Department to discover or note any unsatisfactory material will not relieve the Contractor of his responsibility for providing a complete operable CMS installation as called for under the terms of the Contract. Specifically describe any deviation from the Contract requirements and Specifications in the submittal documents along with a detailed description of the reason for the deviation.

### D. CMS Environmental Operating Conditions

The equipment, materials, and systems will be installed in harsh environmental conditions and shall perform without failure to the performance levels defined within this specification. The normal AC power input, ambient air temperature, and ambient humidity are expected to be:

AC power input voltage 120 VAC, 60 Hz

Air temperature -20 °F (-28 °C) to 105 °F (40.0 °C)

Humidity 20 to 100 percent

It is further expected that under extreme conditions these values may deviate substantially from those normally experienced. As such, the equipment, materials, and systems shall perform to the level of performance or functionality defined within this specification without noticeable degradation under conditions outside of that normally experienced.

Conduct performance testing, in the presence of the Engineer, to demonstrate that the performance requirements and the CMS functionality are met. Ensure that all CMS assemblies and components are designed and tested to perform without degradation of performance or functionality within the environmental conditions defined within NEMA TS-4-2004 Section 2.1.5.. Demonstration of compliance is required under testing laboratory conditions to the extent of these NEMA standards.

### E. Component Minimum Design Criteria

1. General

Ensure that all electrical, electronic, or electromagnetic components used in any CMS assembly have a minimum design life of not less than 10 years operating 24 hours per day under the environmental conditions defined under the acceptance test described within this specification. Use only components de-rated by 50 percent with regard to applied voltage and power dissipation unless otherwise specified so that material shortening of life or shift in values is minimized. All electrolytic capacitors used to filter circuits shall be de-rated by at least 150 percent of their normally operating voltage. All components shall be second sourced with the exception of specialty items for which the Contractor demonstrates that no commercially available second source component will meet the design or performance requirements of the CMS Specification.

2. CMS Pixels

Use only materials for the fabrication of the pixel display modules that will not be damaged by direct exposure to sunlight.

### F. Acceptance Testing

1. General

This section describes Contract acceptance procedures for permanent CMS installations.

Unless otherwise noted in this Contract, develop, provide all equipment for, and perform all acceptance testing for all permanent changeable message sign installations. Develop detailed and thorough test procedures with full test plan descriptions, test and measurement equipment listings, and test results data sheets based upon the testing requirements defined within this specification. As part of the submittal requirements specified in Subsection 631.1.03, provide the following test plans for Engineer approval:

- Pre-Installation Test Plan
- Proof of Performance Test Plan
- Acceptance Test Plan

Use only test plans approved by the Engineer. Provide all necessary testing equipment, facilities, communications, transportation between test sites, and test documentation. Have a complete copy of all materials and equipment submissions and all documentary items on hand at all acceptance testing sessions.

At the conclusion of a test for a given CMS or for the CMS system, provide a thorough and detailed test report that documents the test process and the results of each portion of the testing. Provide a complete listing of test results. Deliver two (2) printed copies and one electronic copy on CD of this report to the Engineer within ten (10) calendar days after conclusion of that test.

Perform all testing in the presence of the Engineer and/or his representatives. Upon receipt of the Contractor's test report for a given CMS or system acceptance test, the Engineer will provide a written acceptance or rejection of that test within ten (10) calendar days.

If the results of a given test are rejected, the Contractor will be notified of the specific reasons for rejection. Make all necessary corrections and revisions to the subject materials and/or equipment and any accompanying documentary items. Upon completion of all necessary corrections and revisions, request a retest in writing. Include in the request for a retest a complete written summary of all corrections and revisions performed and, if applicable, revised documentary items. Do not commence with retesting without the Engineer's prior approval. Conduct all retests in accordance with all requirements of the

initial test. The successful completion of any phase of the testing will not relieve the Contractor of his obligation to fulfill any of the requirements of the Specifications.

2. Pre-Installation Testing

Perform pre-installation testing on each type and size changeable message sign in accordance with this specification. The pre-installation testing will be used to verify compliance and to ensure the operation, serviceability, and reliability of each sign prior to installation. Successful completion of the pre-installation testing is required prior to installation of any CMS assembly.

Develop a Pre-Installation Test Plan that includes all of the requirements of the NEMA TS-4-2004, latest version/addendum, and those additional requirements specifically defined within this specification.

During all pre-installation testing, test a complete CMS assembly for each sign type. A complete CMS assembly is defined as all elements included within the controller cabinet and the cabinet, and all elements included within the sign housing and the sign housing, as well as the interconnection cables and connectors. Configure and connect each CMS assembly as in the final field installation configuration. First perform the vibration and physical shock portions of the NEMA testing for each sign assembly. The vibration and physical shock (g-loads) portion of the tests need not be applied to the entire sign housing but representative assemblies of the display, display driver, power supply and distribution, and communication subassemblies mounted in the sign housing may be assembled as a representation of a complete CMS. Include at least one of each CMS assembly in the representative CMS subjected to the vibration and g-load shock test. Expose a complete CMS controller and controller cabinet assembly to the full NEMA tests described herein as well as the other tests parameters described within this specification. Expose a complete sign housing and display of each type and size to the temperature, humidity, and electrical shock tests defined within the NEMA tests.

Develop software and supply a laptop test computer for the pre-installation testing which communicates with the CMS using the NTCIP protocol stack. Demonstrate all commands to and all responses from the CMS, available in the protocol, using the test computer. Monitor all commands and responses through the use of a recording data analyzer.

Supply an environmental test chamber to perform environmental testing. The test chamber shall be capable of containing the CMS controller cabinet and an operational representation of the sign assembly that includes at least one of each type of operational assembly installed in the sign housing and provide a display capable of displaying at least one character in each sign row. The minimal display configuration shall be such that a test message containing text and graphics is viewable during the testing. During ambient temperature and humidity environmental testing, configure a complete CMS assembly. Provide an environmental chamber capable of achieving and sustaining, with the equipment and material placed in the chamber to be tested, temperatures of -30 °F (-34 °C), +70 °F (20 °C), and +130 °F (54 °C). During these temperatures, apply humidity levels to the maximum non condensing values obtainable, consistent with the temperature, to the equipment under test. Input power and signal lines shall have transient voltages applied as well as power interruption during the environmental testing sessions. Alternately, the entire sign, controller, and controller cabinet may be mounted in a modified refrigerated trailer that is capable of exposing the CMS assembly to the temperature and humidity extremes defined within the NEMA tests.

Commence with Pre-Installation Testing only after meeting all of the following requirements:

- All equipment and materials submissions associated with the CMS controller and housing have been approved by the Engineer.
- All documentary items as specified have been approved by the Engineer.
- The Engineer has approved the Pre-Installation Test Plan, testing schedule, and travel arrangements

Do not perform testing during any State or Federal holiday. Complete any given pre-installation testing session within five (5) consecutive GDOT working days unless otherwise approved by the Engineer. Successfully complete all pre-installation testing prior to installation of a CMS in the field.

3. Proof of Performance Testing

Perform Proof of Performance Testing on each permanent changeable message sign in accordance with the Specifications. The Proof of Performance Testing will be used to verify compliance with the Specifications and to ensure the proper installation and operation of each changeable message sign after all of the equipment and materials are placed in the field and all of the signs are made operational.

Perform the following functional testing using the test software and the laptop computer provided for testing:

- Demonstrate 100 percent compliance with the NTCIP protocol stack operating within an automated poll-response environment.
- Demonstrate every feature of the CMS controller and sign display assembly via direct connect and modem communications.
- Demonstrate fault-free operation of the CMS assembly under test when subject to 500 cycles of status request command and response operations between the CMS and the test software.
- Demonstrate fault-free operation of the CMS assembly under test when subjected to 1000 cycles of message download command, message download response, message display command, message display response, CMS status command, and CMS status response. Perform one complete cycle in 20 seconds or less with a CMS message constructed such that a character message fills every available character space on a two phase message. Set the phase time on to three seconds for each phase and the off time to zero seconds.

Record all communication between the test software and the CMS under test using an HP 4952A or equal protocol analyzer. Record serial data captured by the protocol analyzer on media printable from the protocol analyzer to an ANSII character printer. Provide the test results to the Department as part of the Proof of Performance test results.

Commence with Proof of Performance Testing at a given CMS location only after meeting all of the following requirements:

- All work required in the Plans and Specifications for that CMS location is completed.
- All Pre-Installation Testing for all CMS in the project has been successfully completed. All communications between the given CMS location and the central control facility has been established and tested as functional.
- The Proof of Performance Test Plan and testing schedule have been approved by the Engineer

Do not conduct testing during any State or Federal holiday. Complete any given Proof of Performance Testing session within five (5) consecutive GDOT working days unless otherwise approved by the Engineer.

4. Acceptance Testing

Perform Acceptance Testing on the entire CMS system in accordance with this specification. The Acceptance Testing will be used to verify that the entire CMS system was designed, constructed, installed, and operates as a complete system per the Plans and Specifications.

Perform the following operational performance testing using NaviGAtor software:

- Demonstrate 100 percent compliance with the NTCIP protocol stack operating within an automated poll-response environment.
- Demonstrate every feature of the CMS controller and sign display assembly via direct connect and modem communications.
- Demonstrate fault-free operation of the CMS assembly under test when subject to 500 cycles of status request command and response operations between the CMS and NaviGAtor software.
- Demonstrate fault-free operation of the CMS assembly under test when subjected to 1000 cycles of message download command, message download response, message display command, message display response, CMS status command, and CMS status response. Perform one complete cycle in 20 seconds or less with a CMS message constructed such that a character message fills every available character space on a two phase message. Set the phase time on to three seconds for each phase and the off time to zero seconds.

Record all communication between NaviGAtor software and the CMS under test using an HP 4952A or equal protocol analyzer. Record serial data captured by the protocol analyzer on media printable from the protocol analyzer to an ANSII character printer. Provide the test results to the Department as part of the Acceptance Test results.

Commence with Acceptance Testing only after meeting all of the following requirements:

- Complete all work required in the Plans and Specifications for the entire Contract, including the Contractor’s adjustment of the sign alignment on the sign support system, dimming system, test messages, communications, and test software.

- Successfully complete all Proof of Performance Testing for all CMS in the project.
- The Engineer has approved the Acceptance Test Plan and testing schedule.

Conduct no testing during any State or Federal holiday. Complete the Acceptance Testing session within five (5) consecutive GDOT working days unless otherwise approved by the Engineer.

### G. Burn-In Period

1. General Requirements

Provide a 30-day burn-in period for all work and equipment included in the Contract. The burn-in period shall consist of the field operation of the changeable message sign system in a manner that is in full accordance with the changeable message sign system requirements of the Plans and Specifications. An acceptance test procedure is not required for the system burn-in.

Conduct only one (1) burn-in period on the entire Contract. Commence with the burn-in period only after meeting all of the following requirements:

- All work required in all Contract documents for CMS (may be combined with construction contract) (except this burn-in period) has been completed and inspected by the Engineer.
- Successfully complete all Acceptance Testing and corrective items.

Commence with the burn-in period upon written authorization by the Department to commence. Terminate the burn-in period 30 consecutive days thereafter unless an equipment malfunction occurs. Stop the burn-in period for the length of time any equipment is defective. After repairing the equipment so that it functions properly, resume the burn-in period at the point it was stopped.

Successful completion and acceptance of the burn-in period will be granted on the 30th day unless any equipment has malfunctioned during the 15th through 30th day of the burn-in period. If any equipment has failed during the 15th through 30th day, final acceptance will be withheld until all the equipment is functioning properly for 15 days after repair.

When a specific piece of equipment has malfunctioned more than three times during the 30 day burn-in period, replace that equipment with a new unit and repeat the 30 day burn-in period.

2. Contractor Responsibilities

During the burn-in period, maintain all work under this Contract in accordance with the Specifications. Restore any work or equipment to proper operating condition within 12 hours after notification.

3. Department Responsibilities

Department responsibilities during the burn-in period will be as follows:

- Expeditious notification of Contractor upon failure or malfunction of equipment
- In the event that the Contractor does not provide the services enumerated above under his Contract responsibilities, the Department or its authorized agents may in the interest of public safety take emergency action to provide for adequate traffic control. Pay any costs incurred as a result of these emergency actions. Such action by the Department will not void any guaranties or warranties or other obligations set forth in the Contract.

4. Burn-In Period Acceptance

The Department will make burn-in period acceptance after satisfactory completion of the required burn-in period and on the basis of a comprehensive field inspection of the complete CMS system in accordance with the Specifications. Upon burn-in period acceptance but prior to Final Acceptance of the entire Contract, maintain the complete CMS system in accordance with the requirements of Subsection 631.3.07.

### H. CMS Controller

Provide a CMS controller unit with a design mean time between failures (MTBF) of a minimum of five years of continuous operation in the outdoor environment as calculated by a means approved by the Engineer.

## 631.3.07 Contractor Warranty and Maintenance

### A. General

Provide a clearly stated Manufacturer support (usual and customary warranties) period for all equipment and materials furnished and installed as part of the pay item for CMS equipment and materials. Include in warranty and support, all contractor or manufacturer activities related to maintenance, removal and replacement of parts and materials during the period of support. Begin the Manufacturer support upon successful completion of the Proof of Performance Testing, as outlined in Subsection 631.3.06.F. All Manufacturer warranties shall be continuous throughout the period and state that they are subject to transfer to the Department. Manufacturer support during the warranty period for the Department shall include a technical support phone line, and the ability to provide immediate replacement parts/material for both warranty and non-warranty repair.

### B. Support

Provide full technical support (for both parts and labor) for the period from the installation of all of the CMS in this contract until final acceptance of the contract for all Contractor supplied CMS components.

Provide support that covers maintenance and any defects in materials and workmanship for all system components. Make any replacements required during the support period without additional charge for labor, equipment and system components and other materials required. Support all system components notwithstanding any supplier's warranties whether written or implied.

During the support period, enter a precise description of repair work performed into the log book (supplied by the Department and located in the CMS controller cabinet and at the central control facility).

### C. Response and Notification

Clearly identify in writing the designated contact person and alternate for liaison with the Department. The Department will designate representatives and alternates as contact persons for the control center and the field equipment and provide this information to the Contractor. Communicate with the Department’s designated representative, or alternate, prior to undertaking any maintenance or emergency repairs. Allow the Department's staff the option to accompany the Contractor's staff during the performance of component failure identification and corrective action, during maintenance activities, and during emergency repairs performance. Record all repair and maintenance activity log entries into field cabinet documents and at the control center in the log books provided by the Department.

Respond to emergency repair calls by the Department's coordinator of maintenance or the designated alternate. The Department's coordinator of maintenance or alternate will enter the time of the call and the time of arrival of the Contractor in an emergency repairs log book at the control center. This log book will be made available to the Contractor for his inspection upon request. Response time to reach the site of the malfunction shall be no more than three hours between 0900 hours and 1800 hours Monday to Friday, excluding State or Federal holidays; and six hours at any other time. Take no more than 24 hours from time of receiving notification to have the sign repaired to full functionality, meeting all requirements of the Specifications and confirmed by the Department representative, exclusive of requirements for the coordination of lane closure.

## 631.3.08 Training

### A. General

Prepare and conduct training courses on the system for Department personnel and persons designated by the Engineer. A total of up to 20 GDOT designated personnel will attend the training sessions.

Conduct two types of training courses. The first type is for the engineering and operator personnel (one-day course). The second is for the maintenance personnel (one-day course).

Carry out training on dates mutually agreeable to the Engineer and to the Contractor. Notify the Engineer by giving 30 days notice of intent to carry out the training so that arrangements for attendance can be made. Develop the courses specifically for the system, assuming no prior knowledge of the communications, electronic or changeable message sign technology used. Provide a location to hold the courses that is an acceptable indoor and comfortable location near the project area. If requesting that the training be conducted away from the project area, pay all costs associated with travel and accommodation

of all the students. A member of the Contractors staff with intimate experience with this Contract shall attend the courses and provide answers to any inquires.

Provide a draft of the course material to the Engineer as specified in Subsection 631.1.03.O. Allow adequate time for reviews and revisions to ensure that the courses are held within the designated dates.

Training instructors shall be technically knowledgeable, competent, and proficient in the English language. Instructors shall have the following experience:

- Three (3) years in the design, maintenance, and implementation of CMS
- Taught at least one (1) training course within the last twelve (12) months

**B. Training Content**

Include an introductory level briefing to familiarize attendees with the CMS subsystem prior to the conduct of any acceptance testing of the CMS. A separate operator and engineering course shall include an overview of subsystem elements, the theory of operation of components, operating procedures and capabilities, and software applications. Involve "hands-on" use of all CMS equipment installed in the control center. Provide a separate technician level course to include relevant topics in electronics and communications interfaces. Provide a detailed description and explanation of the theory of operation of major CMS components; operation, test and installation procedures; troubleshooting, diagnostics and maintenance to the replaceable module level, including the use of test equipment and diagnostic tools, installation and alignment techniques during training. The technicians' level course shall also show how to use the system documentation to operate, diagnose, maintain, and expand the system. The technician level course shall also involve the "hands-on" use of the system, laptop computer and software, system test equipment, and any other Contractor supplied equipment.

## 631.4 Measurement

**A. CMS**

CMSs are measured for payment by the type and number actually installed, complete, functional and accepted. Unless otherwise specified in the Plans, include with a CMS installation, at a minimum, furnishing and installing the following:

- CMS controllers.
- All electrical, electronic, or electromagnetic components used in any CMS assembly, including but not limited to capacitors, potentiometers, resistors, semiconductor devices, transformers, inductors, circuit breakers, switches, terminal blocks, wiring, cabling, harnesses, indicators, light emitting modules, driver boards, sign control logic boards, opto-isolation cards, light sensors, sign electronics power supply, pin and socket connectors, PCB connectors, wire connectors, PCB assemblies, fans, and filters.
- All CMS housing components including, but not limited to, the housing assembly and mounting hardware, CMS platform and housing door, and maintenance safety eyebolts.
- Cabinet equipment, including but not limited wiring, conductors, terminal blocks, surge suppression
- Power cables to connect 120V circuits between the CMS controller unit and CMS housing equipment power distribution area.
- All weather heads, vertical conduit risers and conduit hardware on the CMS support pole for power service, grounding, and communications.
- All hardware and materials necessary to provide electrical power service to the CMS field location as shown in the Plans, including, but not limited to, vertical sections of conduit and conduit hardware. The Department will pay for horizontal runs of conduit separately as described in Section 682. The Department will pay for electrical power service assembly separately as described in Section 939.
- All cables, connectors, hardware, interfaces, supplies, and any other items necessary for the proper operation and function of any CMS system component with any other CMS system component.
- Development, installation, testing, and documentation of all software associated with the CMS controller unit.

Supply the following components as support material for all light emitting diode (LED) sign projects:

- LED Display modules 3 each, per sign
- LED drivers 3 each, per sign
- DC Power supplies 1 each, per sign
- Electronic Light Sensor assembly 1 each, per sign
- Sign control logic boards 1 each, per sign
- Fans 1 of each type, per sign

In addition for projects installing:

- One to nine CMS signs, provide one full CMS controller unit for ground cabinet and one CMS controller for sign housing
- Ten to fifteen CMS signs, provide two full CMS controller units for ground cabinet and two CMS controllers for sign housing
- More than fifteen CMS signs, provide three full CMS controller units for ground cabinet and three CMS controllers for sign housing

Include any miscellaneous labor, material, equipment, or services not specifically mentioned but required to make a complete and operational CMS installation within the CMS sign pay item as no separate payment will be made for same.

**B. LED modules (Furnish Only)**

LED modules units are measured for payment by the number actually furnished and accepted.

**C. Power Supplies (Furnish Only)**

Power supplies are measured for payment by the number actually furnished and accepted.

**D. Sign Control Logic Board (Furnish Only)**

Sign control logic boards are measured for payment by the number actually furnished and accepted.

**E. Opto-Isolation Card (Furnish Only)**

Opto-isolation cards are measured for payment by the number actually furnished and accepted.

**F. Electronic Light Sensor (Furnish Only)**

Light sensors are measured for payment by the number actually furnished and accepted.

**G. Fan (Furnish Only)**

Fans are measured for payment by the number actually furnished and accepted.

**H. Filter (Furnish Only)**

Filters are measured for payment by the number actually furnished and accepted.

**I. CMS Controller (Furnish Only)**

CMS controllers are measured for payment by the number actually furnished and accepted.

**J. Testing**

Testing is measured as a lump sum for full delivery of testing and acceptance requirements of all CMS included in the Contract.

### K. Training

Training is measured as a lump sum for all supplies, equipment, materials, handouts, travel, and subsistence necessary to conduct the training.

### 631.4.01 Limits

Not applicable

## 631.5 Payment

### A. CMS

CMSs are paid for at the Contract Unit Price. Payment is full compensation for furnishing and installing the CMS.

CMS components are paid for at the Contract Unit Price. Payment is full compensation for furnishing each component.

Payment at 100 percent of the Contractor and vendor certified invoice price of materials to be permanently incorporated into the work will be allowed provided the Engineer determines that all requirements of the Specifications have been met. All partial payments shall be subject to the maximum Contract pay item increments defined for the particular Contract and subject to the Department's retainage requirements.

For all CMS materials and equipment, payment at 100 percent of the material or equipment invoice price up to a maximum of 75 percent of the Contract pay item bid price will be allowed on a per each basis provided the Engineer determines that the following requirements have been met per each:

- Successfully complete all Pre-installation testing.
- Deliver all CMS housing, display, wiring equipment and materials to the designated project area.
- Place the CMS in proper temporary storage.
- Submit a complete draft documentation package to the Engineer for review and approval for all of the CMS equipment, systems, controller and laptop software, and proof of performance testing.

For all communications materials and equipment, payment of 100 percent of the Contract pay item bid price will be allowed on a per unit basis provided the Engineer determines that the 30 days of the burn-in period have been successfully completed.

Payment for CMSs is made under:

| | | |
|---|---|---|
| Item No. 631 | CMS | Per Each |
| Item No. 631 | Pixel Unit | Per Each |
| Item No. 631 | Light Emitting Module | Per Each |
| Item No. 631 | Lamp | Per Each |
| Item No. 631 | Driver Board | Per Each |
| Item No. 631 | Sign Control Logic Board | Per Each |
| Item No. 631 | Opto-Isolation Card | Per Each |
| Item No. 631 | Light sensor | Per Each |
| Item No. 631 | Sign Electronics Power Supply | Per Each |
| Item No. 631 | Fan | Per Each |
| Item No. 631 | Filter | Per Each |
| Item No. 631 | CMS Controller | Per Each |

**B. Testing**

The Department will pay for testing performed as prescribed by this Item, measured as provided under Measurement at the Lump Sum Contract Bid Price.

Payment for testing is made under:

| | | |
|---|---|---|
| Item No. 631 | Testing | Lump Sum |

**C. Training**

The Department will pay twenty-five (25%) of the total contract bid amount for training upon approval of the Training Plan. The Department will pay the remaining seventy-five (75%) after completion of all training as described in Subsections 631.3.08. The total sum of all payments cannot exceed the original contract amount for this item.

Payment is made under:

| | | |
|---|---|---|
| Item No. 631 | Training | Lump Sum |

## 631.5.01 Adjustments

Not applicable